

## SPH4U Practice Exam

### Modified True/False

Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.

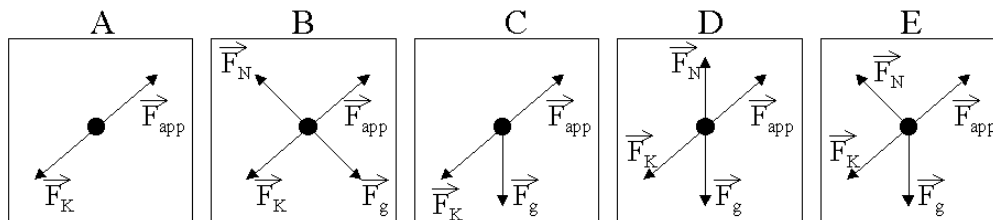
- \_\_\_\_\_ 1. The slopes of position-time, velocity-time, and acceleration-time graphs represent velocity, acceleration, and *displacement*, respectively. \_\_\_\_\_
- \_\_\_\_\_ 2. Provided that a boat always points *perpendicular to the current* in a river, the time it takes the boat to cross is independent of the strength of the current. \_\_\_\_\_
- \_\_\_\_\_ 3. The normal force  $\vec{F}_N$  that acts on an object is *always equal* in magnitude and opposite in direction to the gravitational force  $\vec{F}_G$  that is acting on it. \_\_\_\_\_
- \_\_\_\_\_ 4. A car accelerates from rest when a traffic light turns green. A cup of coffee that was sitting on the dashboard of the car falls into the driver's lap. The driver could rightly argue that the cup's apparent motion *was due to its inertia*. It had a tendency to stay still and the car accelerated from beneath it. \_\_\_\_\_
- \_\_\_\_\_ 5. For an object travelling with uniform circular motion, its instantaneous velocity is always directed *toward the centre of the circle*. \_\_\_\_\_
- \_\_\_\_\_ 6. If Earth's mass and radius were both one half their present values, the acceleration due to gravity on the surface of the Earth would be *four times its present value*. \_\_\_\_\_
- \_\_\_\_\_ 7. The maximum work a force can do on an object occurs when the force is *parallel* to the direction of motion. \_\_\_\_\_
- \_\_\_\_\_ 8. If the net force acting on a system of objects is zero, the linear momentum of the system is conserved *for any number of objects*. \_\_\_\_\_
- \_\_\_\_\_ 9. When the charge on both spheres is doubled, the electric force is *increased by a factor of four*. \_\_\_\_\_
- \_\_\_\_\_ 10. The secondary maxima in single-slit interference are *narrower and dimmer* than the central maximum. \_\_\_\_\_
- \_\_\_\_\_ 11. Time is *absolute and universal*. \_\_\_\_\_
- \_\_\_\_\_ 12. The work function is the amount of energy required to *remove an electron* by light in the photoelectric effect. \_\_\_\_\_

### Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

- \_\_\_\_\_ 13. A football player successfully kicks a field goal through the uprights situated at the south end of the stadium. What are the directions of the instantaneous velocity and acceleration, respectively, of the football at the peak of its trajectory?
  - a. south, south
  - b. up, south
  - c. south, down
  - d. south, up
  - e. down, down
- \_\_\_\_\_ 14. The area under a velocity-time graph represents
  - a. acceleration
  - b. displacement
  - c. instantaneous velocity
  - d. distance
  - e. average velocity
- \_\_\_\_\_ 15. Which of the following is NOT considered to be one of the "fundamental forces"?
  - a. gravity
  - b. friction
  - c. strong nuclear
  - d. weak nuclear
  - e. electromagnetic

16. The free-body diagram of a block being pushed up a rough ramp is best represented by



- a. A  
b. B  
c. C  
d. D  
e. E

17. A passenger on a Ferris wheel of diameter 22 m makes one complete revolution every 45 s. What is the passenger's centripetal acceleration?

- a.  $19 \text{ m/s}^2$   
b.  $13 \text{ m/s}^2$   
c.  $0.43 \text{ m/s}^2$   
d.  $0.21 \text{ m/s}^2$   
e.  $0.068 \text{ m/s}^2$

18. A 75-kg parachutist jumps from a plane at a height of 1.2 km. At the instant he leaves the plane, his gravitational potential energy compared to the plane is

- a.  $8.8 \times 10^2 \text{ J}$   
b.  $-8.8 \times 10^3 \text{ J}$   
c.  $8.8 \times 10^5 \text{ J}$   
d.  $-8.8 \times 10^5 \text{ J}$   
e.  $0 \text{ J}$

19. A net force of 12 N changes the momentum of a 250-g ball by 3.7 kg·m/s. The force acts for

- a. 0.31 s  
b. 0.81 s  
c. 1.2 s  
d. 3.2 s  
e. 44 s

20. Two charged spheres are 5.00 cm apart. One sphere has a charge of  $2.50 \times 10^{-4} \text{ C}$  and the other sphere has a charge of  $3.20 \times 10^{-5} \text{ C}$ . Assuming  $k = 9.00 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$ , the electric force between the two spheres is

- a.  $1.44 \times 10^1 \text{ N}$   
b.  $4.44 \times 10^{-20} \text{ N}$   
c.  $2.25 \times 10^{19} \text{ N}$   
d.  $2.88 \times 10^{-4} \text{ N}$   
e.  $4.44 \times 10^{-18} \text{ N}$

21. Light must travel as a transverse wave because it

- a. can be polarized  
b. can travel through a vacuum  
c. slows down and bends toward the normal  
d. undergoes diffraction  
e. disperses when travelling through a glass prism

22. The length of a horizontal metre stick moving at  $0.75c$  is

- a. 1.00 m  
b. 0.66 m  
c. 0.44 m  
d. 0.56 m  
e. 1.51 m

23. The momentum of a photon with a wavelength of 635 nm is

- a.  $4.21 \times 10^{-40} \text{ kg} \cdot \text{m/s}$   
b.  $1.04 \times 10^{-27} \text{ kg} \cdot \text{m/s}$   
c.  $9.57 \times 10^{26} \text{ kg} \cdot \text{m/s}$   
d.  $1.04 \times 10^{-36} \text{ kg} \cdot \text{m/s}$   
e.  $4.21 \times 10^{-31} \text{ kg} \cdot \text{m/s}$

24. The radius of Mercury is  $2.57 \times 10^6 \text{ m}$ . If  $g = 3.52 \text{ N/kg}$  on the surface of Mercury, the mass of Mercury is

- a.  $3.49 \times 10^{23} \text{ t}$   
b.  $9.70 \times 10^{23} \text{ t}$   
c.  $9.70 \times 10^{23} \text{ kg}$   
d.  $3.49 \times 10^{22} \text{ kg}$   
e. none of the above

## Short Answer

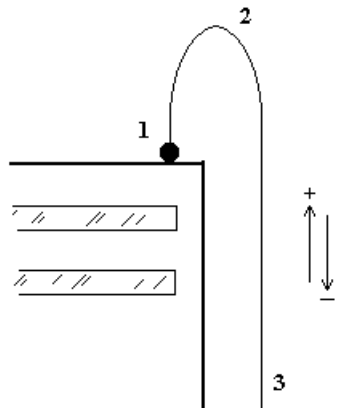
25. If you can hurl a ball so that its initial speed is 30 m/s, what is the widest river you can throw it across?
26. What is the speed of an 1800 kg car with a momentum of  $3.0 \times 10^4$  kg·m/s?
27. What is the speed of an electron in a television tube, if its mass is  $9.1 \times 10^{-31}$  kg, and its kinetic energy is  $9.2 \times 10^{-18}$  J?
28. Two charged spheres 10 cm apart attract each other with a force of  $3.0 \times 10^{-6}$  N. What force results from each of the following changes, considered separately?
  - (a) Both charges are doubled and the distance remains the same.
  - (b) An uncharged, identical sphere is touched to one of the spheres, and then taken far away.
  - (c) The separation is increased to 30 cm.
30. A student doing Young's experiment measures a distance of 6.0 cm between the first and seventh nodal points on a screen located 3.0 m from the slit plate.
  - (a) If the slit separation is 220  $\mu$ m, what is the wavelength of the light being used?
  - (b) What is the colour of the light?

## Problem

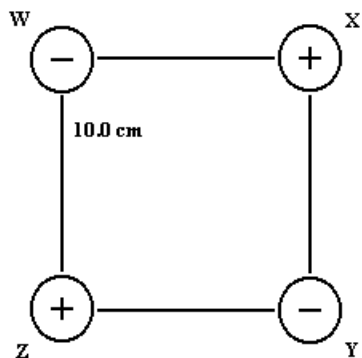
31. Snoopy is flying his plane, the Sopwith Camel, in search of the Red Baron. He flies with a constant speed of 120 km/h relative to the air, and makes instantaneous turns, when necessary. He follows a perfectly square path on the ground, using north-south and east-west roads as a guide for each of the 60 km sides. On a day when there is a steady 60 km/h wind blowing diagonally across the square (say from the northeast) how long does the trip take?
32. A bullet is projected horizontally at 300 m/s from a height of 1.5 m. Ignoring air resistance, calculate how far it travels horizontally before it hits the ground. (Assume that the ground is level.)
34. A steel ball of mass 0.50 kg, moving with a velocity 2.0 m/s, strikes a second ball of mass 0.30 kg, initially at rest. The collision is a glancing one, causing the first ball to be deflected by an angle of  $30^\circ$ , with a speed of 1.50 m/s. Determine the velocity of the second ball after the collision, giving both its speed and direction.
35. A linear elastic spring is 15.0 cm long. When the upper end is held in the hand and a 500 g mass is suspended from the lower end, its length becomes 22.0 cm. If the hand is now jerked quickly upward, the spring first extends to a length of 28.5 cm, then the mass starts to move up. The hand is then held still.
  - (a) Calculate the acceleration with which the mass first begins to move.
  - (b) Calculate the speed of the mass when the length of the spring becomes 22.0 cm again.
  - (c) Calculate the length of the spring when the mass comes to rest at its highest point.

36. A ball of mass 0.25 kg is thrown vertically upward from the roof of a building 18 m high with a speed of 16 m/s, and just misses the building on the way down, as shown.

- (a) To what vertical height above Earth does the ball rise?  
 (b) With what vertical velocity does the ball hit the ground?



37. Point charges W, X, Y, and Z each have the same magnitude charge of  $4.46 \times 10^{-6} \text{ C}$ . Two of the charges are positive as shown and two are negative. The corners of the square are 10.0 cm long. Calculate the net force on each of the point charges. Draw vector diagrams for each point charge.



38. Calculate the potential difference needed to accelerate sulfur-32 ions with a charge magnitude of  $3.2 \times 10^{-19} \text{ C}$  and a mass of  $5.35 \times 10^{-26} \text{ kg}$  into a mass spectrometer, with a uniform 3.7-T magnetic field. The radius of the curved path is 1.15 cm.

## SPH4U Practice Exam

### Answer Section

#### MODIFIED TRUE/FALSE

- |   |             |           |
|---|-------------|-----------|
| 1. ANS: F, jerk<br>LOC: FM1.02                            | REF: K/U    | OBJ: 1.2  |
| 2. ANS: T<br>LOC: FM1.02                                  | REF: K/U    | OBJ: 1.5  |
| 3. ANS: F, not always equal<br>LOC: FM1.01                | REF: K/U    | OBJ: 2.1  |
| 4. ANS: T<br>LOC: FM1.05                                  | REF: K/U    | OBJ: 2.5  |
| 5. ANS: F, tangent the circle<br>LOC: FM1.04              | REF: K/U    | OBJ: 3.1  |
| 6. ANS: F, two times its present value<br>LOC: FM1.06     | REF: K/U    | OBJ: 3.3  |
| 7. ANS: T<br>LOC: EM1.01                                  | REF: K/U    | OBJ: 4.1  |
| 8. ANS: T<br>LOC: EM1.02                                  | REF: C      | OBJ: 5.2  |
| 9. ANS: T<br>LOC: EG1.02                                  | REF: K/U    | OBJ: 7.2  |
| 10. ANS: T<br>LOC: WA2.02                                 | REF: I      | OBJ: 10.2 |
| 11. ANS: F, not absolute; it is dependent on the observer |             |           |
|   | REF: K/U    | OBJ: 11.2 |
|   | LOC: ME1.05 |           |
| 12. ANS: T<br>LOC: ME1.03                                 | REF: K/U    | OBJ: 12.1 |

#### MULTIPLE CHOICE

- |            |          |           |             |
|------------|----------|-----------|-------------|
| 13. ANS: C | REF: K/U | OBJ: 1.4  | LOC: FM1.03 |
| 14. ANS: B | REF: K/U | OBJ: 1.1  | LOC: FM1.01 |
| 15. ANS: B | REF: K/U | OBJ: 2.1  | LOC: FM1.01 |
| 16. ANS: E | REF: K/U | OBJ: 2.1  | LOC: FM1.01 |
| 17. ANS: D | REF: K/U | OBJ: 3.1  | LOC: FM1.04 |
| 18. ANS: E | REF: K/U | OBJ: 4.3  | LOC: EM1.01 |
| 19. ANS: A | REF: K/U | OBJ: 5.1  | LOC: EM1.01 |
| 20. ANS: D | REF: C   | OBJ: 7.2  | LOC: EG1.03 |
| 21. ANS: A | REF: K/U | OBJ: 10.1 | LOC: WA1.01 |
| 22. ANS: B | REF: I   | OBJ: 11.2 | LOC: ME1.05 |
| 23. ANS: B | REF: I   | OBJ: 12.1 | LOC: ME1.03 |
| 24. ANS: E | REF: K/U | OBJ: 6.1  | LOC: EM1.06 |

#### SHORT ANSWER

25. ANS:

$$\Delta d_h = \frac{v_1^2 \sin 2\theta}{a_g}$$

$$= \frac{\left(30 \text{ m/s}\right)^2 \sin 90^\circ}{9.8 \text{ m/s}^2}$$

$$= 91.8 \text{ m, or } 92 \text{ m}$$

REF: K/U, MC      OBJ: 1.4  
 MSC: P

LOC: FM1.03

KEY: FOP 5.13, p.202

26. ANS:

$$p = mv$$

$$v = \frac{p}{m}$$

$$\frac{3.0 \times 10^4 \text{ kg} \cdot \text{m/s}}{1800 \text{ kg}}$$

$$= 17 \text{ m/s}$$

REF: K/U      OBJ: 5.1  
 MSC: P

LOC: EM1.01

KEY: FOP 8.8, p.327

27. ANS:

$$E_k = \frac{1}{2}mv^2$$

$$v^2 = \frac{2E_k}{m}$$

$$= \frac{2\left(9.2 \times 10^{-18} \text{ J}\right)}{9.1 \times 10^{-31} \text{ kg}}$$

$$= 20.2 \times 10^{12} (\text{m/s})^2$$

$$v = 4.5 \times 10^6 \text{ m/s}$$

REF: K/U      OBJ: 4.2  
 MSC: SP

LOC: EMV.01

KEY: FOP 9.2, p.340

28. ANS:

$$(a) \quad F \propto Q_1 Q_2$$

$$\frac{F_2}{F_1} = \frac{(Q_1 Q_2)_2}{(Q_1 Q_2)_1}$$

$$F_2 = F_1 \frac{(Q_1 Q_2)_2}{(Q_1 Q_2)_1}$$

$$= \left( 3.0 \times 10^{-6} \text{ N} \right) (2)(2)$$

$$= 1.2 \times 10^{-5} \text{ N}$$

$$(b) \quad F_2 = F_1 \frac{(Q_1 Q_2)_2}{(Q_1 Q_2)_1} \quad \text{where } (Q_1)_2 = \frac{1}{2} (Q_1)_1$$

$$= \left( 3.0 \times 10^{-6} \text{ N} \right) \left( \frac{1}{2} \right) (1)$$

$$= 1.5 \times 10^{-6} \text{ N}$$

$$(c) \quad F \propto \frac{1}{d^2}$$

$$\frac{F_2}{F_1} = \frac{d_1^2}{d_2^2}$$

$$F_2 = F_1 \frac{d_1^2}{d_2^2}$$

$$= \left( 3.0 \times 10^{-6} \text{ N} \right) \frac{\left( 10 \text{ cm} \right)^2}{\left( 30 \text{ cm} \right)^2}$$

$$= 3.3 \times 10^{-7} \text{ N}$$

REF: K/U  
MSC: P

OBJ: 7.2

LOC: EG1.03

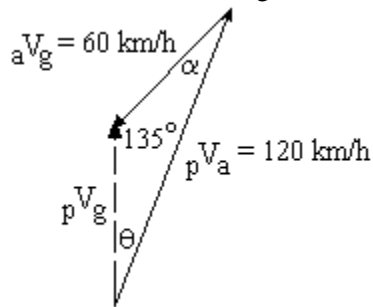
KEY: FOP 15.3, p.583

## PROBLEM

31. ANS:

The pilot flies “off course” in such a way that, when the wind’s velocity is added to his, he is on the intended course.

For the northbound leg,



$$\frac{\sin \theta}{60 \text{ km/h}} = \frac{\sin 135^\circ}{120 \text{ km/h}}$$

$$\sin \theta = \frac{(60 \text{ km/h})(0.7071)}{120 \text{ km/h}}$$

$$= 0.3536$$

$$\theta = 21^\circ$$

$$\therefore \alpha = 24^\circ$$

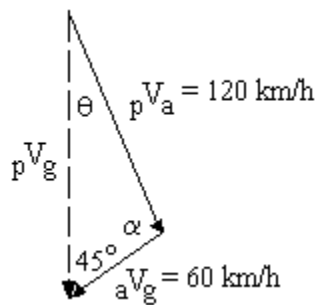
$$\begin{aligned} \text{Then } \frac{pV_g}{\sin 24^\circ} &= \frac{120 \text{ km/h}}{\sin 135^\circ} \\ &= \frac{(0.4067)(120 \text{ km/h})}{(0.7071)} \\ pV_g &= 69 \text{ km/h} \end{aligned}$$

$$\begin{aligned} \therefore \Delta t_N &= \frac{\Delta d_N}{(pV_g)_N} \\ &= \frac{60 \text{ km}}{69 \text{ km/h}} \\ &= 0.87 \text{ h} \end{aligned}$$

Virtually the same situation occurs on the westbound leg, and  $\Delta t_W = 0.87 \text{ h}$ .

For the southbound leg,





$$\frac{\sin \theta}{60 \text{ km/h}} = \frac{\sin 45^\circ}{120 \text{ km/h}}$$

$$\text{and } \theta = 21^\circ$$

$$\therefore \alpha = 114^\circ$$

$$\begin{aligned} \frac{pV_g}{\sin 114^\circ} &= \frac{60 \text{ km/h}}{\sin 21^\circ} \\ &= \frac{(0.9135)(60 \text{ km/h})}{(0.3584)} \\ pV_g &= 153 \text{ km/h} \end{aligned}$$

$$\begin{aligned} \Delta t_s &= \frac{\Delta d_s}{(pV_g)_s} \\ &= \frac{60 \text{ km}}{153 \text{ km/h}} \\ &= 0.39 \text{ h} \end{aligned}$$

Again, the same situation occurs on the westbound leg, so that  $\Delta t_w = 0.39 \text{ h}$ .

$$\begin{aligned} \therefore \Delta t &= \Delta t_N + \Delta t_E + \Delta t_S + \Delta t_W \\ &= 2.5 \text{ h} \end{aligned}$$

REF: K/U  
MSC: P

OBJ: 1.5

LOC: FM1.02

KEY: FOP 3.11, p.127

32. ANS:

$$\Delta d_v = \frac{1}{2} a_g (\Delta t)^2$$

$$-1.5 \text{ m} = \frac{1}{2} \left( - \left( 9.8 \text{ m/s}^2 \right) (\Delta t)^2 \right)$$

$$\begin{aligned} \Delta t &= \sqrt{(0.306 \text{ s})^2} \\ &= 0.553 \text{ s} \end{aligned}$$

$$\begin{aligned} \Delta d_h &= v_h \Delta t \\ &= \left( 300 \text{ m/s} \right) \left( 0.553 \text{ s} \right) \\ &= 166 \text{ m, or } 1.7 \times 10^2 \text{ m} \end{aligned}$$

REF: K/U

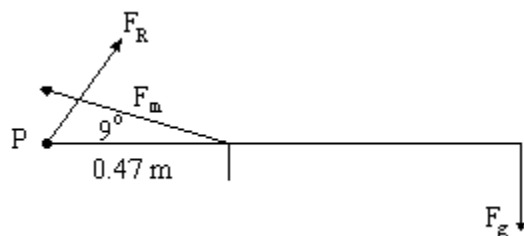
OBJ: 1.4

LOC: FM1.03

KEY: FOP 5.8, p.174

MSC: P

33. ANS:



$$F_g = 40.8 \text{ g N}$$

Taking moments about P:

$$\vec{\tau}_{\text{net}} = \vec{\tau}_m + \vec{\tau}_g + \vec{\tau}_R = 0$$

$$\left( 0.47 \text{ m} \right) \left( F_m \right) (\sin 9^\circ) - \left( 0.70 \text{ m} \right) \left( 40.8 \text{ g N} \right) = 0$$

$$F_m = 3806 \text{ N, or } 3.8 \times 10^3 \text{ N}$$

Force on bottom of vertebrae:

$$\vec{F}_{\text{net}} = \vec{F}_R + \vec{F}_m + \vec{F}_g = 0$$

Horizontal components:

$$0 = F_{R_x} - F_m \cos 9^\circ + 0$$

$$F_{R_x} = 3761 \text{ N}$$

Vertical components:

$$0 = F_{R_y} + F_m \sin 9^\circ - 400 \text{ N}$$

$$F_{R_y} = 400 \text{ N} - 595.7 \text{ N}$$

$$= -195.7 \text{ N}$$

$$F_R = \sqrt{\left(3761 \text{ N}\right)^2 + \left(195.7 \text{ N}\right)^2}$$

$$= 3766 \text{ N}$$

$$= 3.8 \times 10^3 \text{ N}$$

Note the direction of  $\vec{F}_R$  is really below the horizontal.

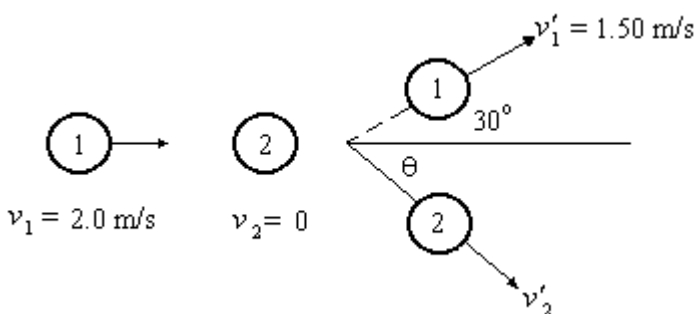
REF: K/U

KEY: FOP 6.9, p.249

MSC: P

34. ANS:

Assume the ball is moving to the right, and deflect at  $[30^\circ \text{ up}]$  as a result of the collision.



Before the collision:

$$\begin{aligned}\vec{p}_{\text{total}} &= \vec{p}_1 + \vec{p}_2 \\ &= m_1 \vec{v}_1 + m_2 \vec{v}_2 \\ &= \left(0.50 \text{ kg}\right)\left(2.0 \text{ m/s}\right)[\text{R}] + 0 \text{ kg} \cdot \text{m/s} \\ &= 1.0 \text{ kg} \cdot \text{m/s} [\text{R}]\end{aligned}$$

After the collision (since momentum is conserved):

$$\vec{p}_{\text{total}} = \vec{p}'_{\text{total}} = 1.0 \text{ kg} \cdot \text{m/s} [\text{R}]$$

$$\text{But } \vec{p}'_{\text{total}} = m_1 \vec{v}'_1 + m_2 \vec{v}'_2$$

$$= 0.75 \text{ kg} \cdot \text{m/s} [\text{R}30^\circ \text{U}] + \left(0.30 \text{ kg}\right)\left(v'_2\right)[\text{R}\theta^\circ \text{D}]$$

Taking components in the L-R direction:

$$1.0 = 0.75 \cos 30^\circ + 0.30 v'_2 \cos \theta \quad (1)$$

Taking components in the U-D direction:

$$0 = 0.75 \sin 30^\circ - 0.30 v_2' \sin \theta \quad (2)$$

From (1)

$$\begin{aligned} v_2' \cos \theta &= \frac{1 - 0.75(0.866)}{0.30} \\ &= 1.168 \end{aligned}$$

From (2)

$$\begin{aligned} v_2' \sin \theta &= \frac{(0.75)(0.500)}{0.30} \\ &= 1.25 \end{aligned}$$

$$\tan \theta = \frac{v_2' \sin \theta}{v_2' \cos \theta}$$

$$= \frac{1.25}{1.168}$$

$$= 1.070$$

$$\therefore \theta = 47^\circ$$

$$\begin{aligned} \text{Then, } v_2' &= \frac{1.168}{\cos 47^\circ} \\ &= 1.7 \text{ m/s} \end{aligned}$$

$$\vec{v}_2 = 1.7 \text{ m/s [R}47^\circ\text{D]}$$

REF: K/U

OBJ: 5.4

LOC: EM1.03

KEY: FOP 8.8, p.330

MSC: P

35. ANS:

$$\begin{aligned} x_0 &= L - L_0 \\ &= 22.0 \text{ cm} - 15.0 \text{ cm} \end{aligned}$$

$$= 7.0 \text{ cm}$$

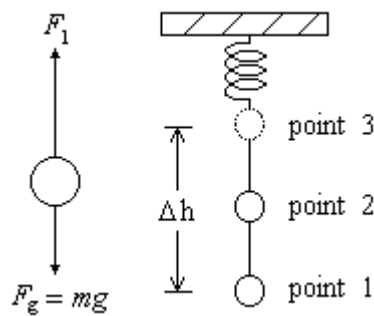
$$F = mg$$

$$= \left( 0.500 \text{ kg} \right) \left( 9.8 \text{ N/kg} \right)$$

$$= 4.9 \text{ N}$$

$$\begin{aligned}
 k &= \frac{F}{x_0} \\
 &= \frac{4.9 \text{ N}}{7.0 \times 10^{-2} \text{ m}} \\
 &= 70 \text{ N/m}
 \end{aligned}$$

(a)



At point 1 where the spring is extended to 28.5 cm,  
 $x_1 = 28.5 \text{ cm} - 15.0 \text{ cm} = 13.5 \text{ cm}$

$$\begin{aligned}
 F_1 &= kx_1 \\
 &= (70 \text{ N/m})(0.135 \text{ m}) \\
 &= 9.45 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 F_g &= mg \\
 &= (0.500 \text{ kg})(9.8 \text{ N/kg}) \\
 &= 4.9 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 \therefore a &= \frac{F_{\text{net}}}{m} \\
 &= \frac{(9.45 - 4.9) \text{ N}}{0.500 \text{ kg}} \\
 &= 9.1 \text{ m/s}^2
 \end{aligned}$$

(b) At any point in its path, the total energy of the system is given by  
 $E_T = E_k + E_g + E_e$

If we assume that the reference level of  $E_g$  is at the lowest point, point 1, when  $L = 28.5 \text{ cm}$ , then at that point

$$\begin{aligned}
 E_{T_1} &= E_{k_1} + E_{\epsilon_1} + E_{e_1} \\
 &= 0 + 0 + \frac{1}{2} kx_1^2 \\
 &= \frac{1}{2} \left( 70 \text{ N/m} \right) \left( 0.135 \text{ m} \right)^2 \\
 &= 0.638 \text{ J}
 \end{aligned}$$

Thus, at point 2, when  $L = 22.0 \text{ cm}$   
 $x_2 = 22.0 \text{ cm} - 15.0 \text{ cm} = 7.0 \text{ cm}$

$$\begin{aligned}
 0.638 \text{ J} &= E_{k_2} + E_{\epsilon_2} + E_{e_2} \\
 &= \frac{1}{2} mv_2^2 + mgh_2 + \frac{1}{2} kx_2^2 \\
 0.638 \text{ J} &= \frac{1}{2} \left( 0.500 \text{ kg} \right) v_2^2 + \left[ \left( 0.500 \text{ kg} \right) \left( 9.8 \text{ N/m} \right) \left( 0.285 \text{ m} - 0.220 \text{ m} \right) \right] + \frac{1}{2} \left( 70 \text{ N/m} \right) (0.070 \text{ m})^2 \\
 0.638 \text{ J} &= \left( 0.250 \text{ kg} \right) v_2^2 + 0.319 \text{ J} + 0.172 \text{ J} \\
 v_2^2 &= 0.588 \text{ J/kg} \\
 v_2 &= 0.77 \text{ m/s}
 \end{aligned}$$

(c) At point 3, when  $v = 0$  at the highest point,  $\Delta h$ , above point 1  
 $x_3 = 28.5 \text{ cm} - \Delta y - 15.0 \text{ cm}$

$$= \left( 13.5 \text{ cm} \right) - \Delta y$$

$$\begin{aligned}
0.638 \text{ J} &= E_{k_3} + E_{\xi_3} + E_{e_3} \\
&= 0 + mg\Delta h + \frac{1}{2}k(0.135 - \Delta h)^2 \\
0.638 \text{ J} &= \left(0.500 \text{ kg}\right)\left(9.8 \text{ N/m}\right)\Delta h + \frac{1}{2}\left(70 \text{ N/m}\right)(0.135 - \Delta h)^2 \\
638 &= 4900\Delta h + (35\,000)\left(0.0182 - 0.27\Delta h + \Delta h^2\right) \\
638 &= 4900\Delta h + 638 - 9450\Delta h^2 + 35\,000\Delta h^2 \\
35\,000\Delta h^2 - 4550\Delta h^2 &= 0 \\
\Delta h &= 0, \text{ or } \Delta h = \frac{4550}{35\,000} \\
&= 0.13 \text{ m}
\end{aligned}$$

Therefore, the length of the spring is  $28.5 \text{ cm} - 13 \text{ cm} = 15.5 \text{ cm}$ , stretched by only  $0.5 \text{ cm}$ .

REF: K/U                      OBJ: 4.5                      LOC: EM1.05                      KEY: FOP 10.8, p.402  
 MSC: P

36. ANS:

(a) The total energy of the system consisting of the ball and Earth remains constant at all points on the 1 to 2 to 3 path, and is equal to the sum of the initial kinetic energy and the gravitational potential energy. Assuming that the zero level of  $E_g$  is the surface of Earth,

$E_{\text{total}} = E_k + E_g$  at all points.

Therefore, at point 1:

$$\begin{aligned}
E_{\text{total}_1} &= E_{k_1} + E_{\xi_2} \\
&= \frac{1}{2}mv_1^2 + mg\Delta h_1 \\
&= \frac{1}{2}\left(0.25 \text{ kg}\right)\left(16 \text{ m/s}\right)^2 + \left(0.25 \text{ kg}\right)\left(9.8 \text{ N/kg}\right)\left(18 \text{ m}\right) \\
&= 32 \text{ J} + 44 \text{ J} \\
&= 76 \text{ J}
\end{aligned}$$

At the instant when the ball reaches its maximum height,  $E_{k_2} = 0$ , and all of its energy is in the form of gravitational potential.

$$E_{\text{total}_2} = E_{k_2} + E_{e_2} = E_{\text{total}_1} = 76 \text{ J}$$

$$= 0 + mg\Delta h_2$$

$$76 \text{ J}$$

$$\Delta h_2 = \frac{76 \text{ J}}{\left(0.25 \text{ kg}\right)\left(9.8 \text{ N/kg}\right)}$$

$$= 31 \text{ m}$$

(b) When the ball reaches ground level,  $E_{e_3} = 0$ , and all of its energy is kinetic.

$$E_{\text{total}_3} = E_{k_3} + E_{e_3} = 76 \text{ J}$$

$$= \frac{1}{2}mv_3^2 + 0$$

$$v_3^2 = \frac{2\left(76 \text{ J}\right)}{0.25 \text{ kg}}$$

$$= 608 \text{ (m/s)}^2$$

$$v_3 = -24.7 \text{ m/s, or } -25 \text{ m/s}$$

Identical results are obtained if  $E_g = 0$  is chosen at the roof level of the building, but don't forget that  $E_{e_3}$  will then be negative at ground level.

REF: K/U

OBJ: 4.4

LOC: EM1.05

KEY: FOP 10.4, p.382

MSC: SP

37. ANS:

$$q \text{ of W, X, Y, and Z} = 4.46 \times 10^{-6} \text{ C}$$

$$r = 10.0 \text{ cm} = 0.100 \text{ m}$$

$$F_{\text{net}} = ?$$

We must find the distance across the diagonal to find the force between the diagonal charges:

$$a^2 + b^2 = c^2$$

$$(10.0 \text{ cm})^2 + (10.0 \text{ cm})^2 = c^2$$

$$14.14 \text{ cm} = c$$

The electric force on the charges on the side:



$$F_{\text{side}} = \frac{kq_1q_2}{r^2}$$

$$= \frac{\left(9.00 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right)\left(4.46 \times 10^{-6} \text{ C}\right)^2}{(0.100 \text{ m})^2}$$

$$F_{\text{side}} = 17.9 \text{ N}$$

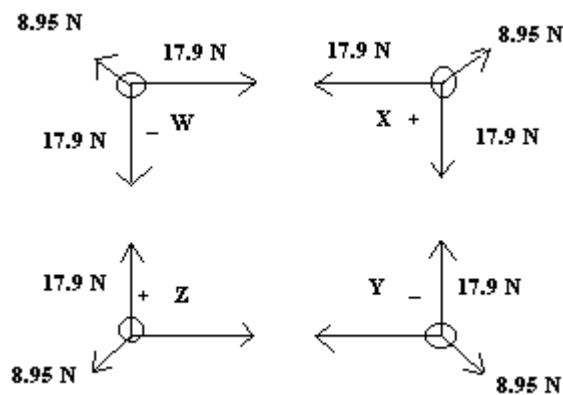
The electric force on the diagonal charges:

$$F_{\text{diagonal}} = \frac{kq_1q_2}{r^2}$$

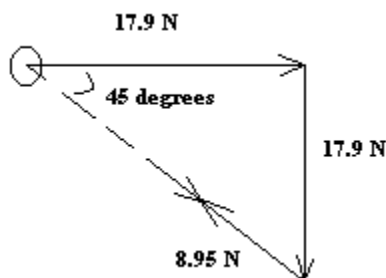
$$= \frac{\left(9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right)\left(4.46 \times 10^{-6} \text{ C}\right)^2}{(0.1414 \text{ m})^2}$$

$$F_{\text{diagonal}} = 8.95 \text{ N}$$

Each point charge experiences the same forces as seen in the vector diagram below.



The magnitude of the force can be found by drawing a vector diagram as shown below. (Charge W is used.)



The length of the final side of the triangle can be found as shown:

$$a^2 + b^2 = c^2$$

$$(17.9 \text{ N})^2 + (17.9 \text{ N})^2 = c^2$$

$$25.31 \text{ N} = c$$

The magnitude of the net force is:

$$\left| \sum \vec{F} \right| = 25.31 \text{ N} - 8.95 \text{ N}$$

$$\left| \sum \vec{F} \right| = 16.36 \text{ N}$$

The magnitude and direction of the vector sum of charge W is:

$$\Sigma \vec{F} = 16.4 \text{ N [right } 45^\circ \text{ down]} \quad (\text{rounded to 3 significant digits})$$

The magnitude and direction of the vector sum of charge X is:

$$\Sigma \vec{F} = 16.4 \text{ N [left } 45^\circ \text{ down]} \quad (\text{rounded to 3 significant digits})$$

The magnitude and direction of the vector sum of charge Y is:

$$\Sigma \vec{F} = 16.4 \text{ N [left } 45^\circ \text{ up]} \quad (\text{rounded to 3 significant digits})$$

The magnitude and direction of the vector sum of charge Z is:

$$\Sigma \vec{F} = 16.4 \text{ N [right } 45^\circ \text{ up]} \quad (\text{rounded to 3 significant digits})$$

38. ANS:

$$q = 3.2 \times 10^{-19} \text{ C}$$

$$m = 5.35 \times 10^{-26} \text{ kg}$$

$$B = 3.7 \text{ T}$$

$$r = 1.15 \text{ cm} = 1.15 \times 10^{-2} \text{ m}$$

$$\Delta V = ?$$

$$-\Delta E_E = \Delta E_K$$

$$q\Delta V = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2q\Delta V}{m}}$$

$$F_M = F_c$$

$$qvB = \frac{mv^2}{r}$$

$$v = \frac{qBr}{m}$$

$$\frac{qBr}{m} = \sqrt{\frac{2q\Delta V}{m}}$$

$$\frac{q^2 B^2 r^2}{m^2} = \frac{2q\Delta V}{m}$$

$$\Delta V = \frac{qB^2 r^2}{2m}$$

$$= \frac{(3.2 \times 10^{-19} \text{ C})(3.7 \text{ T})^2 (1.15 \times 10^{-2} \text{ m})^2}{2(5.35 \times 10^{-26} \text{ kg})}$$

$$\Delta V = 5.4 \times 10^3 \text{ V}$$

The potential difference needed is  $5.4 \times 10^3 \text{ V}$ .